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(54) Bending machine

(57) It is described a tube bending machine having a supporting frame (2) on which a tube to be bent (4) is disposed. Right and left forming dies (7, 8) act on the tube (4). A bending tool (9) moved by a rocking arm (21) carries out bending of the tube around the forming dies.

The bending tool (9) is also radially movable close to and away from the forming dies, to perform a controlled and precise tube bending.

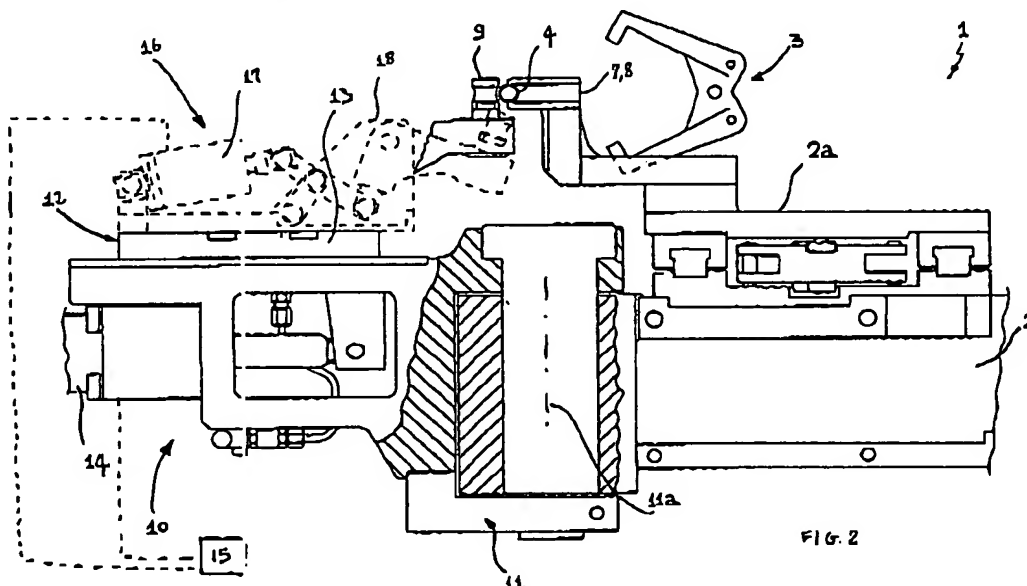


Fig. 2

EP 0 990 471 A1

bending machine in accordance with the present invention;

- Fig. 4 is a diagrammatic perspective view of the machine shown in Fig. 3;
- Fig. 5 is a diagrammatic view of a portion relative to grip means of the tube bending machine of the invention.

[0017] With reference to the drawings, a tube bending machine, particularly intended for carrying out right and left bends in accordance with the present invention, has been generally identified by reference numeral 1.

[0018] The tube bending machine 1 has a fixed supporting frame 2 above which grip means 3 for holding at least one tube to be bent 4 operates. The grip means 3 usually consists of a chuck 5 movable by translation relative to the supporting frame in a direction 6 parallel to the longitudinal axis of the tube 4 to be submitted to processing.

[0019] In this way the grip means is capable of ensuring a desired axial positioning of the tube 4 on the supporting frame 2, in particular relative to the first and second forming dies, 7 and 8, operatively associated with a front head 2a of the supporting frame itself.

[0020] These forming dies 7 and 8 are disposed in mutual side by side relationship and are active on the tube for executing right or left bends, as better described in detail in the following.

[0021] Practically, tube 4 extends between the first and second forming dies disposed in mutual side by side relationship and is bent around the first one or second one of these dies, depending on whether right or left bends respectively are wished to be made.

[0022] In order to carry out bending of the tube, close to the forming dies 7 and 8 a bending tool 9 is present which consists of a roller for example or a small pulley selectively cooperating with the first one or second one of the forming dies.

[0023] The bending tool 9 is connected with the supporting frame upon interposition of movement means 10 enabling the bending tool to be moved relative to the forming dies.

[0024] In detail, the movement means 10 comprises a first movement member 11 moving the bending tool 9 along a curved trajectory for carrying out bending of the tube around the first or second forming dies.

[0025] The first movement member 11 is preferably made up of a rocking arm in engagement with the supporting frame for oscillation around a rotation axis 11a transverse, and preferably vertical, to the longitudinal axis of the tube extending at an intermediate position between the two forming dies 7 and 8.

[0026] More specifically, the rotation axis 11a around which arm 11 oscillates extends in a vertical symmetry plane of the first forming die with respect to the second one.

[0027] In this manner, the bending centre of the curved trajectory described by the bending tool is sub-

stantially at an intermediate position between the two forming dies.

[0028] In an original manner, the movement means 10 also comprises a second movement member 12 capable of moving the bending tool 9 close to and away from the forming dies along directions transverse to said dies.

[0029] Practically, the second movement member 12 comprises a slide 13 mounted on the rocking arm 11 and connected to the bending tool in a kinematic manner.

[0030] This slide receives action from a first actuator member 14, a fluid-operated cylinder or an electric stepper motor for example, which is also carried by the rocking arm 11 and is capable of moving the slide away from and close to the forming dies 7 and 8 along said transverse directions; as can be viewed from the depicted examples, slide 13 moves radially relative to the forming dies 7 and 8 and carries out a translation relative to arm 11, so as to modify the distance between the bending tool 9 and the forming die intended for use.

[0031] Advantageously, the first actuator member 14 is managed by a control unit 15 controlling the actuator itself in such a manner that a plurality of positions are determined for the bending tool 9 relative to the forming dies along said directions.

[0032] Practically, the bending tool will be able to take the desired distance from the active profile of the forming die being used.

[0033] Still more advantageously, the control unit 15 will be able to act on the actuator member and continuously modify the bending tool position along said transverse directions, i.e. it will be able to carry out a radial movement of roller 9 close to or away from the active profile of the forming die being used, as bending goes on.

[0034] In other words, the control unit is operatively active both on the first actuator member 14 and the actuator member (not shown) causing rotation of arm 11, carrying out control of the radial position of the bending tool or roller 9 according to the parameters set by the user during the whole bending operation, i.e. during rotation of the rocking arm around the forming die being used.

[0035] It is to note that the movement means further comprises a third member 16 which too is operatively interposed between the fixed frame 2 and the bending tool 9 and, in the embodiment shown in Fig. 1, is carried by the rocking arm 11.

[0036] In more detail, in this case, the third movement member 16 is interposed between the slide 13 and the bending tool 9 and moves the latter up and down relative to the forming dies.

[0037] This movement, in combination with the movement imparted by the rocking arm, enables the bending tool to be moved to the right or to the left of the tube, in order to make this tool cooperate with either of the forming dies, depending on requirements.

the roller or bending tool 9 which sets itself to the right or to the left of the tube to be bent, depending on the required type of bending.

[0062] Subsequently, movement of the rocking arm combined with that of the first actuator leads the bending tool to carry out the desired trajectory around the forming die being used.

[0063] It is to note that at each angular position of the rocking arm 11, the radial distance between forming die and bending tool can be continuously adjusted, due to the presence of the first actuator 14 and the control unit 15, thereby achieving a great accuracy in the tube bending.

[0064] When a first bend has been executed, the grip chuck makes the tube to be bent move forward and/or rotate around its own axis.

[0065] Then, there is a new positioning of the bending tool or roller 9 to the right or to the left of the tube to be processed and afterwards a new movement both of the rocking arm 11 and of the first actuator 14.

[0066] If one or more bends are wished to be made by using the auxiliary forming die present at the chuck, the forming dies 7, 8 are opened wide, by virtue of the auxiliary movement unit, and the bending tool or roller are brought close to and in cooperation with said auxiliary forming die 24.

[0067] The invention achieves important advantages.

[0068] Firstly, the tube bending machine in reference enables bends to the right and to the left to be made with an accuracy never reached until now, because not only it is possible to optimize the distance of the bending tool from the forming dies depending on the sizes of said dies and the typology of the tube to be bent, but it is also possible to continuously adjust the radial distance of the bending tool from the forming dies during the whole bending step, i.e. during the angular movement of the rocking arm.

[0069] Due to the possibility of making the bending tool move forward relative to the forming dies, bends of 180 and more degrees can be easily obtained without problems arising in terms of effort concentrations or local material unstabilization because the whole bending step is controlled in a very precise manner.

[0070] As already said, it is also possible to take advantage of an auxiliary forming die positioned at the chuck, which not only offers the possibility of bends having a differentiated diameter as compared with that of the first and second forming dies, but also enables consecutive connections to be made at a short distance from each other, if desired.

[0071] If a head movable in one or two directions is provided, the whole apparatus may be adapted for working with forming dies having differentiated radii and carrying out loading and unloading operations in an independent manner.

[0072] Finally, due to the movement possibilities given to the different parts of the machine and the operating flexibility of the machine itself, and due to the presence

of the control unit capable of managing the movement means, the auxiliary movement unit and also the displacements of the bending head, if the latter is present, any type of bending process can be optimized in the best manner.

Claims

1. A tube bending machine, comprising:

- a fixed supporting frame (2);
- grip means (3) for holding at least one tube to be bent (4), which means is mounted on the supporting frame and is movable relative to the latter for ensuring a desired axial positioning of the tube with respect to the supporting frame itself;
- at least one first and one second forming dies (7 and 8) operatively associated with the supporting frame and disposed in mutual side by side relationship, and defining respective bending axes parallel to each other;
- a bending tool (9) active on said tube and selectively cooperating with the first one or second one of said forming dies (7, 8) to make right or left bends on said tube, respectively;
- movement means (10) for the bending tool (9), which means is operatively interposed between the bending tool and the supporting frame (2) for moving the bending tool between at least one cooperating condition with said first forming die (7) and at least one cooperating condition with said second forming die (8);
- said movement means in turn comprising a first movement member (11) for making the bending tool describe a curved trajectory so as to carry out bending of the tube around one of said forming dies, characterized in that said movement means further comprises a second movement member (12) for moving said bending tool close to and away from the forming dies (7, 8) along directions transverse to said dies.

2. A tube bending machine as claimed in claim 1, characterized in that the first movement member (11) comprises a rocking arm in engagement with the supporting frame (2) around a rotation axis (12) transverse to the longitudinal axis of the tube and preferably substantially vertical.

3. A tube bending machine as claimed in anyone of the preceding claims, characterized in that the second movement member (12) comprises:

- at least one slide (13) associated with said first movement member (11) and arranged for carrying the bending tool (9);

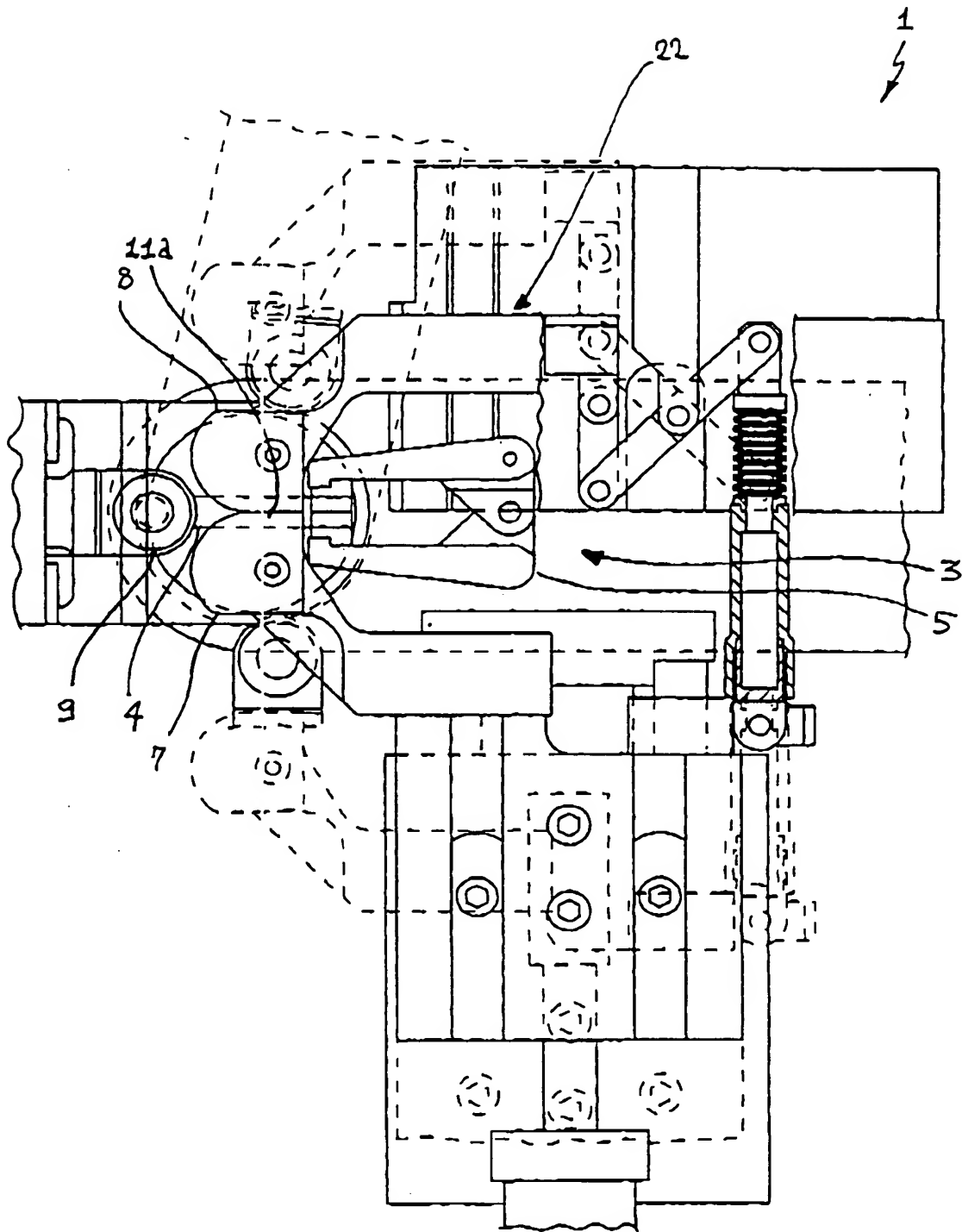


FIG. 1

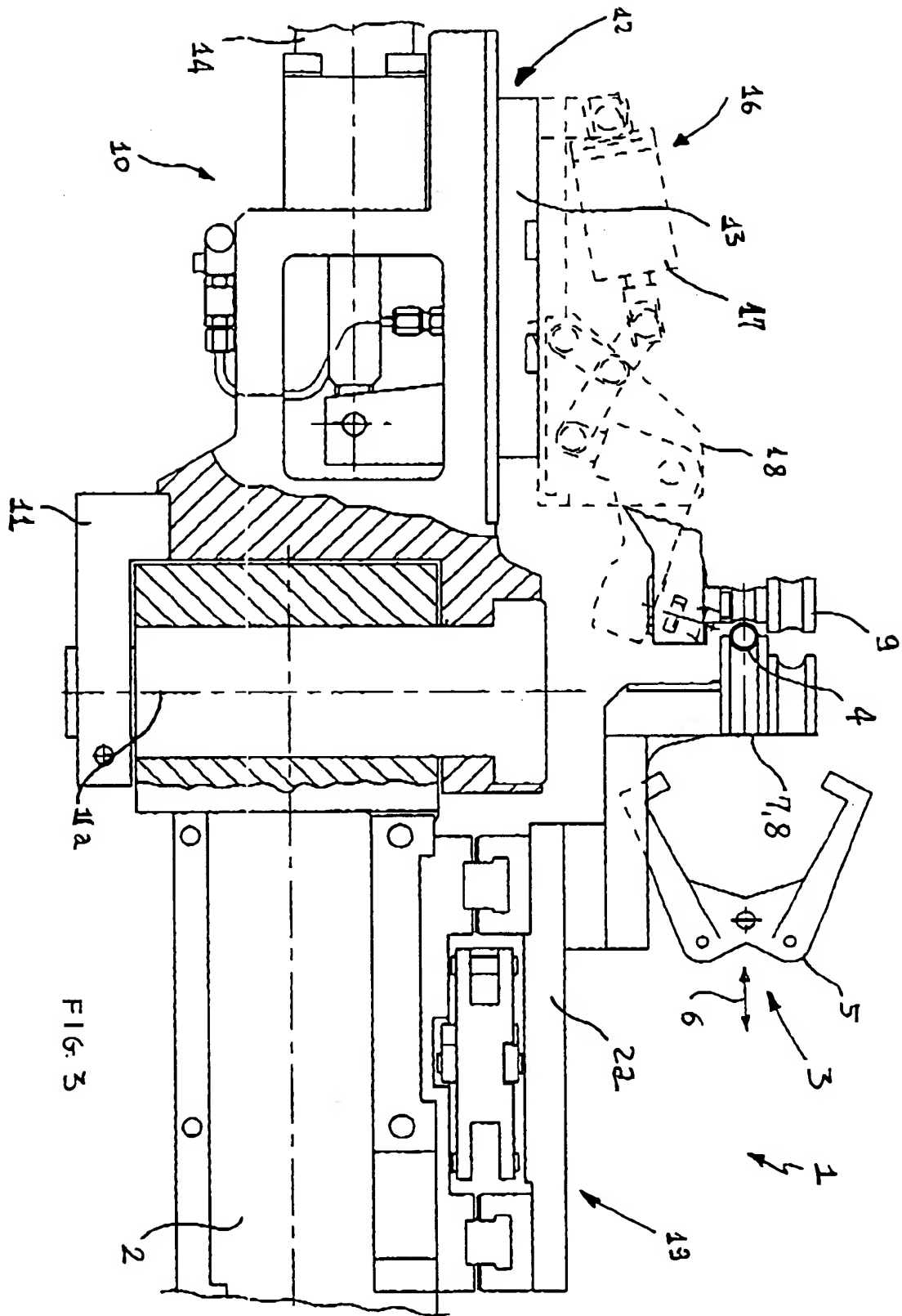


FIG. 3

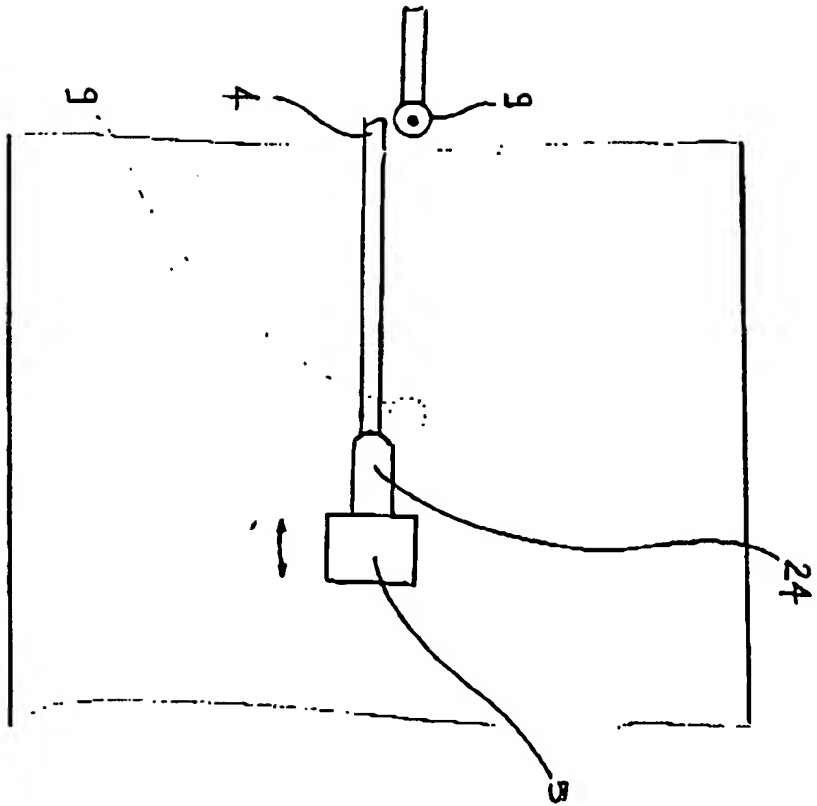


FIG.5

ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-02-1999

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Description

[0001] The present invention relates to a tube bending machine. In particular, the tube bending machine being the object of the invention is intended for bending tubes into right or left bends, due to the presence of a roller or movable bending tool capable of setting itself to the right or to the left of the tube before the beginning of each bending operation.

[0002] It is known that tube bending machines intended for making right and left bends on one and the same tube are generally employed for accomplishing articles such as coils and the like. These machines are provided with a fixed supporting frame on which a chuck for gripping the tube to be bent slides. The chuck is generally movable along the longitudinal axis of the tube for positioning a front portion thereof to the desired region where the bending tools operate.

[0003] In fact, it should be noted that usually at a front or head region of the fixed frame, a first and a second forming dies disposed close to each other are present, as well as a bending tool carried by a rocking arm capable of performing curved trajectories around either of said first and second forming dies, depending on whether right or left bends are wished to be made.

[0004] In more detail, the bending tool usually consists of a roller which, if a right bend is wished to be made, is positioned to the left of the tube to be bent and therefore, through a movement of the rocking arm carrying the roller itself, said roller performs a curved trajectory around the right forming die leading the tube to undergo a deformation according to a shape almost similar to that of the throat present in the forming die.

[0005] If a subsequent left bend is wished to be made, the bending tool or roller will have to step over the tube going to the right of the latter, and then to carry out a curved trajectory around the left forming die in the same manner as previously described. Between two subsequent bends the chuck carried by the supporting frame will execute the necessary axial displacements.

[0006] This type of apparatus has found wide consent on the market in that it enables tubes even provided with many right and left bends alternated with each other to be obtained in a very short period of time without requiring that the tube to be bent should be set in rotation around its own axis; it should be noted in this connection that a 180° rotation of the tube around its own axis may be difficult, above all as the tube bending goes on, due to the possibility of interferences between the already bent tube portion and the machine body, which greatly restrains the operating flexibility of the manufacturing machine taken as a whole.

[0007] In spite of that, it is however to note that tube bending machines for right and left bends of the above described type have proved not to be devoid of drawbacks as well.

[0008] In fact, since the bending roller is in engagement with a rocking arm oscillating around a vertical

axis usually disposed in a symmetry plane between the axes of each of the right and left forming dies, and since the roller is located at some distance from the forming dies themselves, the tube deformation cannot be precise and cannot follow the shape of the forming die in a controlled manner.

[0009] Actually, the obtained bends are close to the shape of the throat present in the forming dies only in an approximate manner.

[0010] Since precision in bends is poor, it is also necessary that some distance should be ensured between one bend and the next one, which makes it substantially impossible to carry out immediately consecutive bends or bends close to connecting regions.

[0011] Beside the above, it is also to point out that the distance between the bending roller and forming die makes it practically impossible to carry out bends at angles close to or higher than 180° without inevitably obtaining poor results in terms of quality and without interfering with other parts of the machine at the back of the bending head.

[0012] In addition to being inaccurate, a bend obtained with the traditional systems, on the other hand, is the result of optimizing the bending roller position relative to the forming dies; this optimization is usually carried out depending on the die diameter, the section and material of the tube to be bent.

[0013] This involves that, by positioning the roller or bending tool at a fixed distance from the forming dies, obviously, an always optimized bend cannot be obtained upon variation of the forming die and/or the tube typology.

[0014] In the light of the above, it is a fundamental object of the present invention to accomplish a tube bending machine, particularly intended for making consecutive right and left bends, capable of operating in a very precise manner, even when 180 or more degree bends are to be executed.

[0015] It is a further object of the invention to provide a tube bending machine capable of being always optimized even when operations with forming dies of differentiated radial sizes or with tubes of differentiated materials and/or sections are executed.

[0016] Further features and advantages will become more apparent from the detailed description of some preferred, non-exclusive embodiments of a tube bending machine in accordance with the invention. This description will be taken hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 is a diagrammatic plan view of a front portion relative to a tube bending machine in accordance with the invention;
- Fig. 2 is a side view partly in section relative to the machine portion shown in Fig. 1;
- Fig. 3 is a side view partly in section similar to Fig. 2 showing a possible alternative solution of a tube

5

EP 0 990 471 A1

6

[0038] The third movement member 16 comprises a second actuator member 17 active on a drive linkage 18, in turn arranged for moving the bending tool along a curved trajectory, preferably lying in a vertical plane.

[0039] It is to note that in the accompanying Figs. 2 and 3 the vertical curved trajectory of the roller has a concavity turned towards the front region of the machine; however, this curved trajectory can obviously have its concavity turned in the opposite way, i.e. towards the rear region of the machine.

[0040] As viewed from Fig. 2, the second actuator member 17 and drive linkage 18 are carried by the moving-along slide mounted on the rocking arm 11.

[0041] As shown in the alternative embodiment diagrammatically illustrated in Fig. 4, it is to note that the forming dies 7 and 8, bending tool 9 and movement means 10 can be carried by a true bending head 19 which is movable relative to the fixed supporting frame.

[0042] In particular, as shown in Fig. 4, the bending head 19 is mounted on the supporting frame 2 close to a front end of said frame, upon interposition of interconnecting means 20 enabling the head to be displaced in at least one first auxiliary direction 21 transverse to the longitudinal axis of the tube to be bent.

[0043] In particular, this first auxiliary direction 21 is preferably vertical, so that a displacement of the forming dies 7, 8 in this direction may be enabled.

[0044] In this case use of forming dies comprising a first and a second forming element 7a, 7b; 8a, 8b will be possible, which elements are superposed on each other, as shown in the example in Fig. 4.

[0045] Typically, the first and second forming elements 7a, 7b; 8a, 8b may have bending radii differentiated from each other so that the machine 1 can automatically carry out bending operations following different radii.

[0046] It is apparent that forming dies having more than two superposed elements can be also provided, that is forming dies with three, four, five or more superposed elements, depending on requirements.

[0047] The vertical travel of head 19 along direction 21 is required to be adequate, i.e. depending on the necessary displacements for selecting each of the superposed elements of dies 7 and 8.

[0048] It is to note that, in order to enable disengagement of the tube from the forming dies disposed mutually in side by side relationship, an auxiliary movement unit 22 is provided which is carried either by the bending head or directly by the supporting frame and is active on the forming dies for moving them from a condition in which they are close to the tube to be bent, to a condition in which they are spaced apart from the tube to be bent (shown in chain line in Fig. 1) and vice versa.

[0049] Preferably, the interconnecting means 20 between the bending head and fixed frame can be in a position to also enable a displacement of the head itself along a second auxiliary direction 23 transverse to the longitudinal axis of the tube to be bent and transverse to said first auxiliary direction 21.

[0050] Generally the interconnecting means between head and frame, enabling the head to move along said first and second transverse directions, consists of respective slides and actuator members (not shown).

[0051] It is to note that the control unit 15 is preferably connected to each of the actuator members intended for carrying out the above described movements of head 19, tool 9, dies 7 and 8 in such a manner that the machine freedom degrees are coordinated in accordance with the program set by the user.

[0052] Should the bending head be movable in two directions, it is clear that the head itself, taken as a whole, can act as a handling member for picking up and laying down the tube from and into loading and unloading stations respectively, typically located close to the tube bending machine.

[0053] Finally, due to the fact that the bending tool 9 can move radially close to and away from the forming dies, said grip means 3 may be provided to comprise an end portion defining an auxiliary forming die 24.

[0054] In this case the second movement member is capable of carrying out such a travel that the bending tool 9 is brought to cooperate with the auxiliary forming die 24, in a condition in which the forming dies 7 and 8 are spaced apart from the tube to be bent.

[0055] In other words, the auxiliary movement unit 22 can be operated for opening the first and second forming dies wide and enabling a movement of the bending tool 9 until the grip means so as to carry out bending of the tube around the auxiliary forming tool 24 that, typically, will have a differentiated shape and/or diameter relative to those of the forming dies.

[0056] Preferably the auxiliary forming tool has a very reduced bending radius and is employed every time bends of small radius or consecutive bends where each bend is provided to be very close to the next adjacent one are required to be made.

[0057] Still with reference to the grip means 3, it is to note that chuck 5, in addition to being movable along the longitudinal axis of the tube to be bent, may be also provided with means for setting the tube in rotation around said longitudinal axis, in order to give the machine more operating flexibility and the capability of carrying out even unflat bends.

[0058] Operation of a tube bending machine in accordance with the invention, described above mainly as regards structure, is as follows.

[0059] Once the tube to be bent has been conveniently positioned on the grip chuck 5, the latter brings a front portion of the tube close to the pair of forming dies 7 and 8 that at a first moment are open wide and spaced apart from each other.

[0060] Due to the intervention of the auxiliary movement unit 22, the forming dies are moved close to each other and brought close to the tube, once the latter has reached the desired axial position.

[0061] When these operations have been completed, the movement means 10 carries out displacement of

9

EP 0 990 471 A1

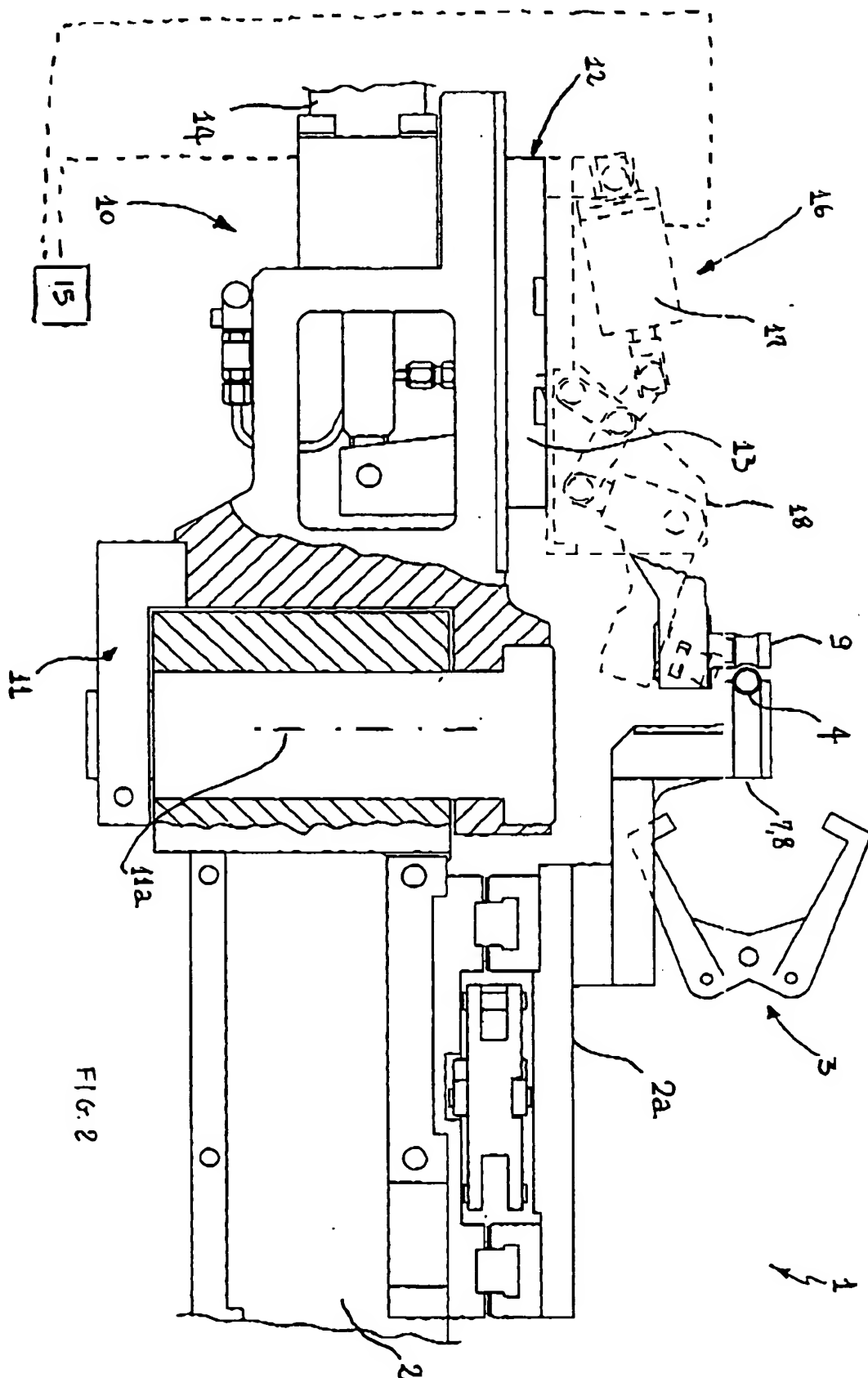
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- a first actuator member (14) also carried by said first movement member (11) and active on said slide so as to move the latter close to and away from the forming dies along said transverse directions;
 - at least one control unit (15) active at least on said first actuator member to determine a plurality of positions of the bending tool (9) relative to the forming dies along said transverse directions.
4. A tube bending machine as claimed in claim 3, characterized in that the control unit (15) is active on the first actuator member (14) to continuously adjust the position of the bending tool relative to the forming dies along said transverse directions.
5. A tube bending machine as claimed in anyone of the preceding claims, characterized in that the movement means (10) also comprises a third member (16) which too is operatively interposed between the fixed frame (2) and the bending tool (9) to move the latter up and down relative to said forming dies (7, 8).
6. A tube bending machine as claimed in claim 5, characterized in that said third movement member (16) comprises a second actuator member (17) active on a drive linkage (18) in turn arranged for moving the bending tool along a curved trajectory, said second actuator and drive linkage being in turn carried by the first movement member (11).
7. A tube bending machine as claimed in anyone of the preceding claims, characterized in that it comprises:
- a bending head (19) associated with the supporting frame (2) and arranged to carry said forming dies (7 and 8), bending tool (9) and movement means (10);
 - interconnecting means (20) between the bending head and the supporting frame to enable a displacement of the head in at least one first auxiliary direction (21) transverse to the axis of the tube to be bent, said forming dies comprising at least one first and at least one second forming elements (7a, 7b; 8a, 8b) superposed on each other.
8. A tube bending machine as claimed in claim 7, characterized in that said first and second forming elements (7a, 7b; 8a, 8b) have respective bending radii differentiated from each other.
9. A tube bending machine as claimed in claim 7, characterized in that the interconnecting means (20) between the head (19) and frame (2) enables a

displacement of the head itself also along a second auxiliary direction (23) transverse to said first auxiliary direction (21) and to the longitudinal axis of the tube to be bent.

10. A tube bending machine as claimed in claims 1 or 7, characterized in that it comprises an auxiliary movement unit (22) carried by said bending head (19) or said supporting frame (2) to move them from a condition in which they are close to said tube to be bent (4) to a condition in which they are spaced apart from said tube to be bent.
11. A tube bending machine as claimed in claim 10, characterized in that said grip means (5) comprises an end portion defining an auxiliary forming die (24), said second movement member (12) being capable of bringing the bending tool to cooperate with the auxiliary forming die in a condition in which said tube to be bent is moved apart from said forming dies.

EP 0 990 471 A1



EP 0 990 471 A1

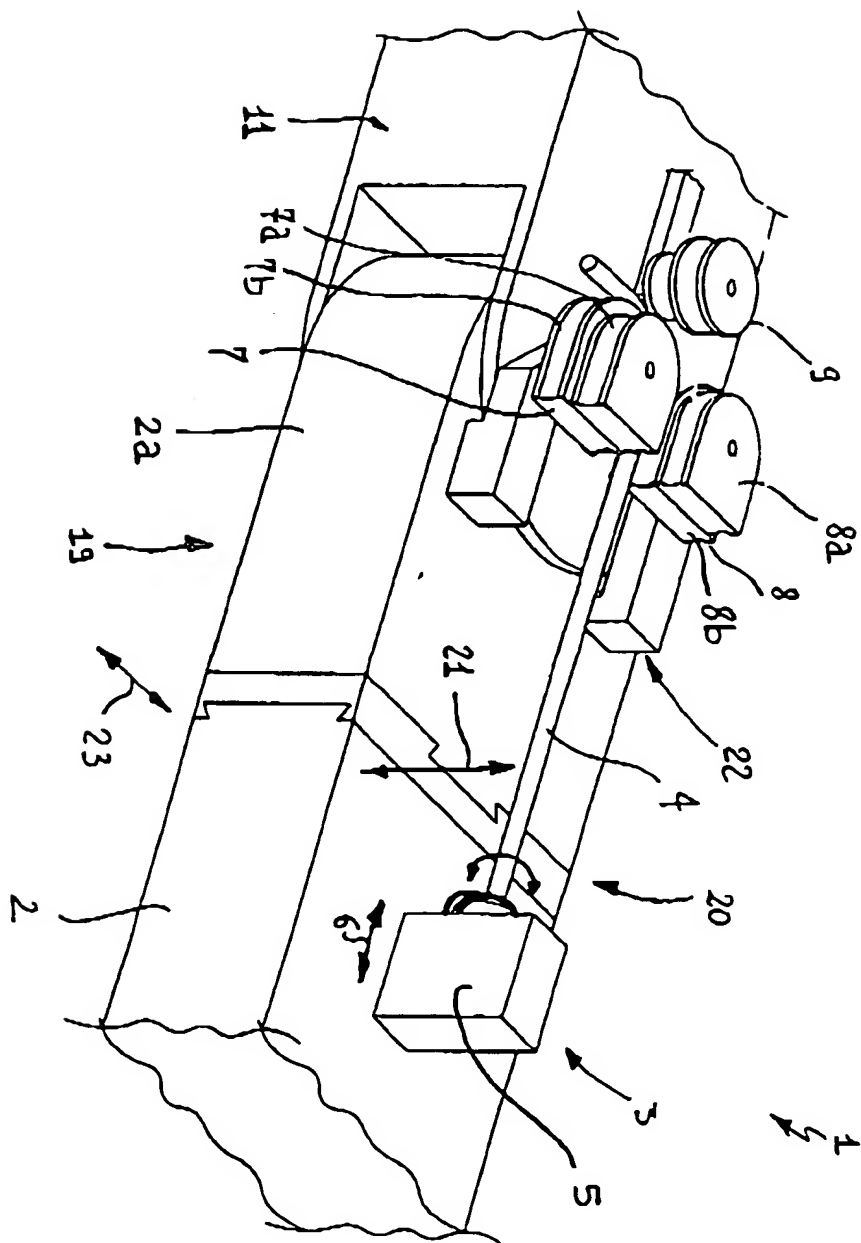


FIG. 4

EP 0 990 471 A1

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EUROPEAN SEARCH REPORT

Application Number
EP 98 83 0579

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 26 February 1999	Examiner Peeters, L
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